

622.09
Ar 43 Do
no. 3, cop. 3

L. H. Whitney

Bulletin No. 79

Oil Series No. 3

University of Arizona Bulletin

Drilling for Oil

BY

MILTON A. ALLEN.



Entered as second class matter November 23, 1915, at the postoffice at Tucson, Arizona, under the Act of August 24, 1912. Issued weekly, September to May.

PUBLISHED BY THE

University of Arizona Bureau of Mines

CHARLES F. WILLIS, *Director*

TUCSON, ARIZONA

1917-18

BIBLIOGRAPHY.

- ARNOLD AND GARFAIS—The prevention of waste of oil and gas from flowing wells in California. U. S. Bureau of Mines, Tech. Paper 42.
- ARNOLD AND GARFAIS—Methods of oil recovery in California. U. S. Bureau of Mines, Tech. Paper 70.
- ARNOLD AND GARFAIS—The cementing process of excluding water from oil wells as practiced in California. U. S. Bureau of Mines, Tech. Paper 32.
- BRANNT, W. T.—Petroleum and Its Products and Natural Gas.
- CRAIG, E. H. CUNNINGHAM—Oil Finding.
- HAGER, DORSEY—Practical Oil Geology.
- KNAPP, I. N.—The use of mud-laden water in drilling wells, Trans. A. I. M. E., Vol. LI.
Cementing oil and gas wells. Trans. A. I. M. E., Vol. XLVIII.
- HIGGEN AND POLLARD—Drilling wells in Oklahoma by the mud-laden fluid method. U. S. Bureau of Mines, Tech. 68. Mud-laden fluid applied to well-drilling. U. S. Bureau of Mines, Tech. Paper 66.
- McLAUGHLIN, R. P.—Protecting California oil fields from damage by infiltrating water. Trans. A. I. M. E., Vol. LII.
- OATMAN, F. W.—Water intrusion and methods of prevention in California oil fields. Trans. A. I. M. E. Vol. XLVII.
- REDWOOD, SIR BOVERTON—Petroleum and Its Products.
- REQUA, M. L.—Comparative Costs of Rotary and Standard Drilling. Trans. A. I. M. E. Vol. LI.
- THOMSON, A. BEEBY—Petroleum Mining.

BIBLIOGRAPHY CONSULTED.

- BRANNT, W. T.—Petroleum and its products and natural gas.
- HAGER, DORSEY—Practical Oil Geology.
- THOMSON, A. BEEBY—Petroleum Mining.

University of Arizona Bulletin

OIL SERIES No. 3

FEBRUARY 20, 1918

DRILLING FOR OIL.

BY MILTON A. ALLEN.

INTRODUCTORY.

This is the third bulletin of the following series:

1. Oil and its geology.
2. Prospecting for oil.
3. Drilling for oil.
4. Laws pertaining to oil.

It is not intended that this bulletin should serve as a book by which the prospector could undertake the drilling of oil wells, but only to show that drilling is a profession by itself.

Drilling for petroleum should in all cases be undertaken by the expert and also under contract, if possible. The conditions which are encountered and which have to be overcome are often great and tax the ingenuity of the expert driller. For this reason, therefore, this bulletin is written to show the oil prospector what is being undertaken when drilling for oil is commenced, and the conditions, troubles and set-backs which may be encountered.

METHODS OF DRILLING.

The methods of drilling for oil or gas are varied in each field to meet local conditions. The method is influenced by many factors such as depth of oil strata, dip of beds, nature and hardness of strata to be pierced, etc.

For prospecting the two following divisions can be made:

1. Portable rig 0-1000 feet.
2. American or Canadian systems 1000-2000 feet.
3. Modification of No. II, 2000-and above.

The question of the selection of a site has been discussed in detail in "Prospecting for Oil." If detailed study and attention has been given the choosing of the well site some knowledge of the strata to be pierced will be had. When the field is a new one the conditions to be met are not so apt to be known. In this instance a method will be chosen that will reach the depth at which it is estimated the oil will be encountered, allowing a fair margin of safety.

THE PORTABLE SYSTEM.

This system is supposed to be capable of drilling to depths of 1500 feet if the strata is easy to drill. It is obviously not good policy to choose this system when the oil strata is estimated to be between 1200-1600 feet deep. A margin of safety should be attained. The advantages of this system as a prospecting rig are that it is self-contained and easy to get into rough, new and unopened country. It also uses casing of moderate diameter. These portable rigs have attachments for the use of rotary methods. When water in large quantity is not available the rotary or flush system cannot be used.

CANADIAN AND AMERICAN SYSTEMS.

When prospecting a new field where practically little is known of the geological conditions, the Canadian system is the safest to adopt. Although the rate of drilling is not so great, this system is able to penetrate almost any strata and cope with all conditions.

The diamond drill is rarely ever used in petroleum drilling.

The Canadian and American systems of drilling are practically identical except that the Canadian system uses wooden rods for boring and the American a rope or cable. It will be understood that more control over the bit is exercised by a rod. However, a combination of the two is sometimes used.

Some of the conditions which are met with will be briefly described.

When steep strata is encountered and the beds are alternately soft and hard the bit tends to follow on the dip of the harder rock, thus deflecting the hole. Again soft sand may be met with and the hole cave. In this event casing must follow drilling very closely. Most rocks will hold up well under drilling for considerable distances before casing is necessary. Where considerable thicknesses of loose caving strata is encountered it will be absolutely necessary to use some form of the flushing system.

Clays, shales and loose ground will hold up well when horizontal, but may give considerable trouble if highly inclined or broken up.

The advantages of a core drilling device over percussion is that the core enables a more exact record of the well to be kept, whereas the percussion system mixes the borings, making exact records impossible; again, it is not always advisable to bail the well. This will be discussed more fully later.

During drilling the importance of a record, especially in pioneer works, cannot be overestimated. The knowledge gained by it may considerably reduce the cost and trouble if any new wells are attempted. Geological evidence is valuable in that it determines in

622.09
Ar 43bo
no. 3
cop. 3

which direction future development is to extend, the number of oil horizons that exist, and where the dangerous water levels are and what their relation is to the oil sands. Oftentimes the driller, in order to complete his contract, will not give the attention to the records that should be given and often a special man is detailed by the contracting party to keep all well records.

CABLE OR AMERICAN SYSTEM.

In this system a rope or cable is used in drilling. The chief equipment consists of,

Power equipment.

Machine for drilling.

72 ft. x 20 ft. derrick.

Drilling tools,

Fishing tools.

Casing elevators.

Cables, wire and rope.

The derrick is used for supporting of the sheave wheels by which lowering and raising of the string of boring tools and casing is accomplished. The height of 72 feet is necessary, as the length of casing and string of tools is great.

The fishing tools are used in the process of extracting lost tools, split casing, etc., and will be described later under "difficulties."

The casing is a wrought iron pipe by which the well is lined. In order that the casing may be lowered into the well at stages as the well progresses a series of decreasing sizes are used. The first casing is driven to as great a depth as it is possible to carry it. By decreasing the size of the hole as depth is attained drilling is facilitated and troubles lessened. A casing at the start may be from 10-14 inches in diameter and may decrease to $3\frac{1}{2}$ inches, depending on the depth of the well.

THE CANADIAN SYSTEM.

The listed outfit for this method is the same as for the previously mentioned system, except that the derrick is but 54 feet high, and the boring tools are wooden rods instead of a cable or rope.

THE RUSSIAN OR GALICIAN SYSTEM.

These systems are modifications of the Canadian methods and use iron rods instead of wood.

DIFFICULTIES.

The difficulties commonly met with in the drilling of oil wells are:

1. Lost tools.
2. Split casing.
3. Caving.
4. Deflected holes.
5. Water trouble.

For lost tools a special set of fishing implements is provided. These may be for extracting the bit or part of the bit. The rope may break and leave the string of tools in the well, or the rods may break; both cases require different tools and methods to recover them.

Split casing has to be extracted or pulled and tools are provided for this. This trouble is caused by defective casing, collapse due to caving or driving the casing too hard.

Caving is brought about by encountering heavy water flows, soft rock or quicksand. The casing usually follows closely upon the drilling when soft strata is encountered. The flushing system is necessary for drilling in sand. One of the systems used to combat caving ground is the mud-laden fluid method. In this method clay is introduced into the well and this acts as a cementing material as well as a pressure agent, keeping out gas and water under pressure.

Caving, if allowed to continue, will bring about the forming of large cavities around the casing and may cause its collapse.

Caving may break the whole string of tools, in which case they will have to be flushed out by water under pressure or drilled out.

Deflected holes are not unusual occurrences. When this occurs cement is poured into the hole, completely filling it, below the deflection.

Water is the great trouble for the oil well man and if it is not properly dealt with it may result in the complete loss of the well and drain out the oil field.

The precautions to be taken in this are the proper fitting of casing at the joints either by swaging or cementing, also by completely cementing the water strata and then drilling through it. This method is even used in the sinking of shafts of large diameter in water-bearing strata. The damage which can be done by water can best be illustrated by a few sketches. In drilling for petroleum, oil-bearing sands may be met with, one below the other, separated by a considerable distance of barren strata; parts of the strata may be water-bearing. The casing of the well at the oil-bearing levels above the main level is usually perforated to allow the oil to enter the well.

For convenience the water trouble may be divided into two classes:

1. *Primary* water is that water below the oil in the oil sand itself.

2. *Secondary* is that water coming into the well from other water-bearing strata through many causes, as defective casing, failure to cement water-bearing strata, failure to cement exhausted oil sands, and flooding by surface water.

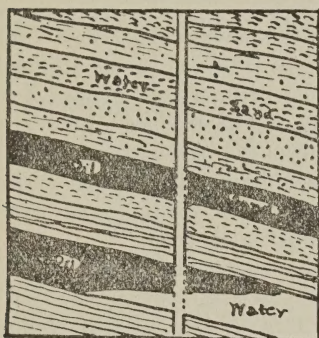


Fig. I

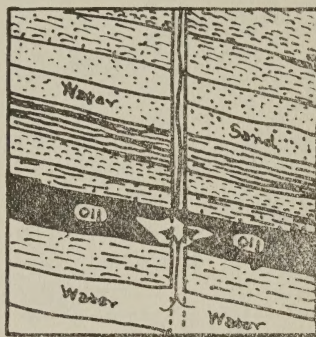


Fig. II

1. As the gas and oil are withdrawn from the oil sands the water gradually takes its place and, where there is only one oil horizon, will indicate the end of the life of the field. In the case where there are two oil horizons, the exhaustion of either one will result in the loss of the other if precautions are not taken as in Figs. I and II. The water may be from a water-bearing sand below caused by drilling a well too deep and penetrating water sands.

The water may come from a sand above and leak into the oil-

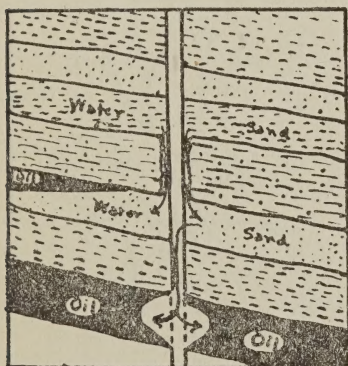


Fig. III

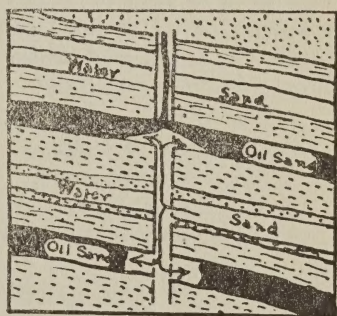


Fig. IV

bearing strata and from there into the well through the perforated casing, thus drowning the well. See Figs. III, IV and V.

In drilling, a strata of caving sand may be met. The removal of the loose sand leaves a large cavity, causing the impervious cover of the oil sand to collapse, producing the results shown in Fig. V.

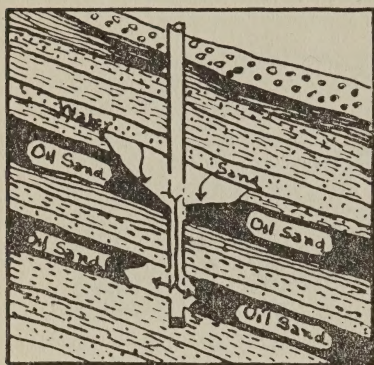


Fig. V

tight by swaging or cementing, withdrawing split casing and cementing both at above and below water-bearing strata.

SPACING WELLS.

Wells should be spaced economically, as spacing naturally influences the life of the well and its production. Improper spacing may cause overproduction and thus loss. Overproduction in a field may cause the loss of the field. Each well influences the production of the well in its immediate neighborhood.

The whole problem is one of economics, and the wells should be placed so as to yield the greatest amount of oil at the least expense. The factors which control a producing well are:

- a. Size of pool.
- b. Thickness of strata.
- c. Number of oil strata.
- d. Porosity of strata.
- e. Area covered by each strata.

The area drained by one well is estimated to be from one acre to ten. Of course this depends on the local conditions, but four or five acres to the well is taken as good practice.

The influence of one well on others is caused by natural fissures

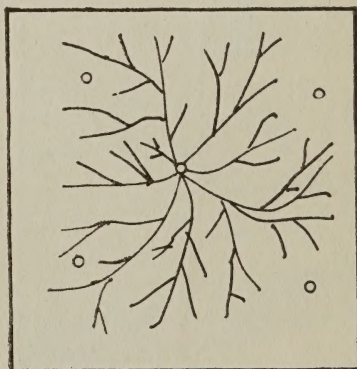


Fig. VI

or fissures which have been caused by relieving pressure or by the blasting of the hole. Fig. VI.

Many wells after they reach the oil-bearing strata require to be blasted before they become productive. The quantity of nitro-glycerine used depends on the condition of the strata. An overload may cause the complete loss of the well. The quantity of nitro-glycerine has varied from 10 to 120 quarts. Care must be taken in exploding the nitro-glycerine at the correct place in the hole.

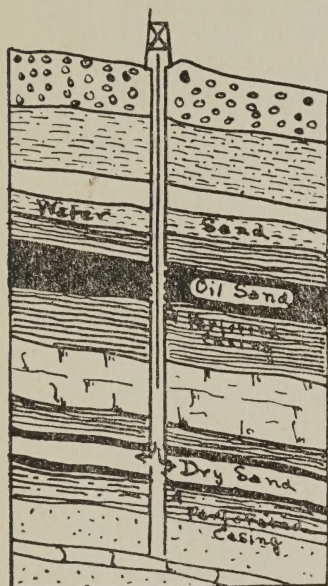


Fig VII

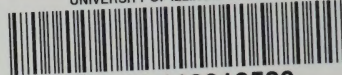
Oil losses may occur through perforated casing being placed in practically barren porous sands to extract the small amount of oil which may be found in them. See Fig. VII. Oil may be spotty, due to the change in porosity of the rocks, shape of sands caused by original deposition, and deep-seated faults. In this event a well may not strike oil although oil is known to exist in the field. Many fields have been abandoned on account of a few dry holes; these fields after careful exploration and study of conditions have afterward become large producers.

COSTS.

The cost of a well depends on whether it is a prospecting well and new in the field or whether the well is being sunk in an old district. Also the economic conditions of the country influence the cost of the first well. The pioneer well in any field always costs the most. Given herewith is a list of the costs which were current in some of the fields of the United States and Mexico.

In contract work the drilling is usually paid for by the foot, the contractor supplying the complete rig for drilling. The owner supplies the cost of derrick and well casing. All work except actual drilling, such as sealing water strata, etc., is paid for by the day.

Costs in the Coalinga field of California for the stand and rig are: \$3.42 per foot, allowing for depreciation of drilling rig and



all overhead charges. This field is situated about two miles from the railroad.

In Mexico the cost of first wells are estimated at \$65,000, this includes wages, supplies, transportation and duty on drill supplies, road-building and upkeep, camp maintenance, etc.

Standard rigs will vary in cost from \$300 to \$750 in the United States, depending on locality. Contracting price, exclusive of tubing, contractor to furnish complete drilling outfit, varies from \$.75 to \$1.50 per foot.

It may be figured, however, that all items will be high in a new field.

Brown Brothers, contractors in the Caddo field of Louisiana, give the cost of one well, including \$300 for an acre lease, as \$9,289. This is for a well of 2,200 feet depth, and includes the price of complete drilling equipment.

In fields in which oil has to be pumped the maintenance and upkeep costs from \$1.00 per well per day to \$5.00 per well per day, depending on the number of wells pumped.

It will be appreciated that the condition brought about by the war has considerably advanced costs in all lines of industry, so these figures can only serve as guides at best. It is also the reason for not going into greater cost detail in this bulletin.

LIFE AND YIELD OF WELLS.

The yield of an oil sand depends on the porosity, degree of saturation and quantity extractible. The life of a well varies with the amount of supply, compactness of oil strata, and gas pressure accompanying the petroleum. It varies from a few months to 20 years or more. The closeness of drilling the wells considerably affects the production. Some wells gush forth tremendous quantities of oil for a short period, then die out. Others may yield moderate quantities for years. The average life of Pennsylvania oil wells is seven years.